Coherent e^+e^- Pair Production in STAR

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We report the observation of e^+e^- pair production via coherent $\gamma\gamma$ interaction ($Au+Au \rightarrow Au^*+Au^*+e^+e^-$) in ultra-peripheral heavy ion collisions. The cross-section of pair production is extremely large due to a high photon flux for $Au+Au$ reactions (proportional to Z^2). In addition, the applicability of perturbation theory becomes questionable because the coupling constant of photons to the nucleus is large($Z\alpha \sim 0.6$ for Au)[1].

The cross-section to produce an e^+e^- pair falls rapidly with increasing invariant mass of the pair. The pairs are peaked away from mid-rapidity. The total transverse momentum of the pairs is limited by the requirement that the photons are produced by coherent Au interactions, where $\Sigma p_\perp < \hbar/R \sim 100 MeV/c$. The STAR Time Projection Chamber (TPC) can only reconstruct individual tracks with transverse momenta of more than $\sim$100 MeV/c, and for the coherent ultra-peripheral pairs the TPC can only reconstruct pairs with the invariant mass above $\sim$100 MeV/c^2. As a result, the overall acceptance for the e^+e^- pairs is very small($< 2\%$). The identification of e^+ or e^- tracks is possible via dE/dx in the momentum range of 100-140 MeV/c. Tracks with such low momenta curve strongly in the magnetic field and do not reach the Central Trigger Barrel, a detector which surrounds the TPC in the pseudorapidity range $|\eta| < 1$ and registeres passage of charged particles. Therefore, triggering on e^+e^- pairs in STAR requires the use of Zero Degree Calorimeters(ZDC), which detect neutrons emitted by the gold nuclei. This happens when the nuclei electromagnetically excite each other into a Giant Dipole Resonance in addition to producing an e^+e^- pair[2].

In the year 2000 data, which was taken at $\sqrt{S_{NN}} = 130 GeV$, we analysed 800,000 events triggered with the ZDCs. We found 30 identified e^+e^- pairs, with individual track momenta in the 100-140 MeV/c range[3]. The $\Sigma p_\perp$ spectrum of these pairs shows a peak at low momenta, which is the signature of coherent $\gamma\gamma$ interactions (Fig. 1). The 2001 data was taken at $\sqrt{S_{NN}} = 200 GeV$ with magnetic fields of 0.5 T and 0.25 T. For the 0.5 T data set, observation of e^+e^- pairs is difficult, because the tracking fails for the tracks with momenta of less than 140 MeV/c due to the high curvature of these tracks. For the 0.25 T data we have about 0.95 million ZDC triggers. The cross-section for the e^+e^- at $\sqrt{S_{NN}} = 200 GeV$ is expected to be higher than at $\sqrt{S_{NN}} = 130 GeV$. The preliminary analysis suggests approximately 50 e^+e^- pairs in the half-field data set.

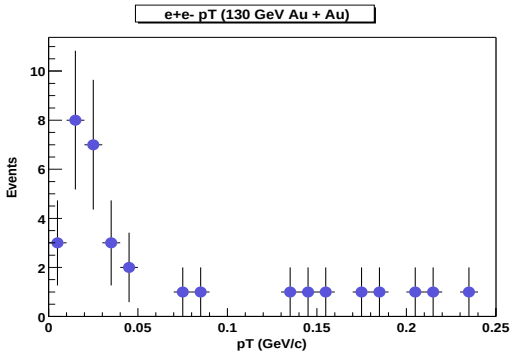

Figure 1: Total transverse momentum of the identified e^+e^- pairs at $\sqrt{S_{NN}} = 130 GeV$.

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[1]G.Baur *et al.*, Coherent $\gamma\gamma$ and γA interactions in very peripheral collisions at relativistic heary ion colliders, hep-ph/0112211.

[2]S. Klein, Ultra-peripheral collisions of relativistic heavy ions, nucl-ex/0108018.

[3]F. Meissner, Coherent γP and $\gamma\gamma$ interactions in ultra-peripheral collisions at RHIC, nucl-ex/0112008.